An Anomalous Pacific Cod Fishery in Juan de Fuca Strait

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July 1986

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1891

87-00249/

Canadian Manuscript Report of Fisheries and Aquatic Sciences

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AN ANOMALOUS PACIFIC COD FISHERY IN JUAN DE FUCA STRAIT

by

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Cat. No. Fs 97-4/1891E ISSN 0706-6473

Correct citation for this publication

Westrheim, S. J. and M. G. Pedersen. 1986. An anomalous Pacific cod fishery in Juan de Fuca Strait. Can. MS Rep. Fish. Aquat. Sci. 1891: 55 p.

ABSTRACT

Westrheim, S. J. and M. G. Pedersen. 1986. An anomalous Pacific cod fishery in Juan de Fuca Strait. Can. MS Rep. Fish. Aquat. Sci. 1891: 55 p.

During 1974-84, Canadian landings of Pacific cod (Gadus macrocephalus) from eastern Juan de Fuca Strait (MSA 19) rose precipitously to a peak of 957 t in 1981, then declined equally sharply to approximately 131 t in 1985. Prior to 1974, Pacific cod was also the principal species landed, but its annual landings rarely exceeded 100 t. Tagging experiments, landing statistics, age-frequencies, gonad condition, diet, and herring distribution were employed to explain, if possible, the anomalous cod aggregation and resulting fishery. The authors concluded that the anomalous cod aggregation in MSA 19 originated from offshore grounds, and that cod were attracted to MSA 19 by an anomalous aggregation of herring inbound to spawn in Georgia Strait.

RESUME

Westrheim, S. J. and M. G. Pedersen. 1986. An anomalous Pacific cod fishery in Juan de Fuca Strait. Can. MS Rep. Fish. Aquat. Sci. 1891: 55 p.

Entre 1974 et 1984, les débarquements canadiens de morue du Pacifique (Gadus macrocephalus) du secteur est du détroit de Juan de Fuca (MSA 19) ont augmenté abruptement pour atteindre un sommet de 957 t en 1981, puis ont diminué aussi brusquement pour s'élever à environ 131 t en 1985. Avant 1974, la morue du Pacifique était également la principale espèce débarquée, mais les débarquements annuels de ce poisson ont rarement dépassé 100 t. On s'est servi d'expériences par étiquetage, de statistiques de débarquement, des fréquences d'âge, de la condition des gonades, du régime alimentaire et de la distribution des harengs pour expliquer, si possible, le rassemblement anormal des morues et la pêche qui en découle. Les auteurs ont conclu que le rassemblement anormal des morues dans la zone MSA 19 avait pour origine les lieux de pêche situés au large et que les morues étaient attirées dans ce secteur par un rassemblement anormal de harengs revenant frayer dans le détroit de Géorgie.

INTRODUCTION

In 1974, a minor trawl fishery for Pacific cod in eastern Juan de Fuca Strait (Fig. 1) began increasing dramatically, and produced substantial landings for the next seven years. Since 1981, landings have been declining, and in 1985 were near the pre-1974 level. Specifically, the fishery is located in Canadian Minor Statistical Area (MSA) 19, which lies off Victoria.

The purpose of this report is to present the results of our investigations into the source(s) of the cod in MSA 19, and the cause(s) of their anomalous aggregation in MSA 19.

MATERIALS AND METHODS

GENERAL

This study utilized information concerning tagging experiments landing statistics, age-frequencies, gonad condition, diet, and herring surveys.

TAGGING EXPERIMENTS

During 1944-79, numerous Pacific cod tagging experiments were conducted off southern British Columbia and northern Washington State. The results of virtually all of these experiments have been published--Gosho (1976), Bargmann (1980), and Westrheim (1982, 1985a, 1985b). The published reports are based on a total of 25,125 Pacific cod tagged and released in Areas 3A, 3B, 3C, 4A, and 4B (Fig. 2).

LANDING STATISTICS

Landings were compiled, by quarter-year, from published records, wherever possible, or from agency computer records. Collection of landing records, by MSA[1], in Washington State began in 1963 (Pattie 1973) and is

[1]During 1963-83, MSAs in Area 4A have had three sets of numbers and boundaries--1963-66, 1967-79, and 1980-83 (Pattie 1985). In this report we have used the set in effect during 1967-79, and adjusted the 1963-66 and 1980-83 data accordingly.

continuous through 1983 (Pattie 1985). Records, by MSA, for British Columbia began in 1945 (Thomson and Yates 1961) and are continuous through 1984 (Leaman 1985). Canada-U.S. landings from major statistical areas (Fig. 2) are reported annually, by month, in the PMFC[2] Groundfish Data Series, which began with the 1956 landings, and is continuing.

Detailed records of landings and effort, by trawling ground, are collected by Port Liaison Officers in the principal ports of British Columbia and Washington State. These "interviewed" landing statistics are stored in computers at the laboratories of the respective agencies.

Landing statistics for MSA 19 were standardized by the method of Westrheim and Foucher (1985b). LPUE-computation employed the qualification method[3]. October-December records were used to test four qualification levels (0, 20, 40, and 60%), because of the substantial landings and continuous time series (Fig. 3; Table 1). The 40% qualification level was selected to minimize the number of landings containing appreciable quantities of spiny dogfish (Squalus acanthias). Actually, for 1974-84, magnitudes and trends of all four LPUEs were virtually identical.

Standardized landing statistics were utilized for stock assessment. Trends in cod landings from MSA 19 were compared with trends from other nearby locations to detect any reciprocal relationships.

AGE-FREQUENCIES

Age-frequencies of Pacific cod landings were estimated from dock-side length-frequency samples by means of the computer method of Foucher and Fournier (1982), based on the generalized method of Schnute and Fournier (1980).

The 1945-84 results for important MSAs in Area 4B, by quarter-year, were reported by Foucher and Giudici (1985). The 1956-82 results for important area-time cells in Area 3C-N were reported by Foucher and Westrheim (1984) and the unpublished 1983-84 update was completed by R. P. Foucher. Age compositions for Washington State landings from MSAs 80 and 86, and Areas 3C-S and 3B, were derived by R. P. Foucher from unpublished length-frequency data provided by the U.S. author.

Comparisons of age-frequencies (in percent) among locations of catch employed the Chi-square test of independence (Dixon and Massey 1969, p. 240), in the form of a 2 x n contingency table, with n - 1 degrees of freedom.

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[2]Pacific Marine Fisheries Commission, Portland, Oregon, USA.

[3]Calculating LPUE from all interviewed landings in which Pacific cod comprised X% of the landing. X = qualification level.

Age-frequencies of Pacific cod landed from MSA 19 during October-December were compared with those landed during the following January-March from nearby inshore MSAs (86, 80, 18, and 17-N) and one offshore location, Amphitrite Bank, the principal spawning area for cod in Area 3C-N (Fig. 4). In addition, comparisons were made of age-frequencies among the appropriate offshore areas (3C-N, 3C-S, and 3B) for landings during April-June and July-September. Comparisons were not made of October-December age-frequencies from MSA 19 with offshore areas during the preceding April-June and July-September, because of the prolonged recruitment of age-2 cod, and the initial recruitment of age-1 cod in October-December.

GONAD CONDITION

Gonad condition was recorded by Canadian Port Liaison Officers for individual Pacific cod sampled for length and sex, primarily during November-March. Gonad criteria are those of Westrheim (1977; Table 12), and are contained in Table 2.

DIET

Stomach contents, on a general basis, are recorded by Canadian Port Liaison Officers while sampling for length and sex of landed cod. A description of methods, and results for cod landed from offshore banks, are contained in Westrheim and Harling (1983).

HERRING SURVEYS

During 1968-81, a series of echo-sounder and/or midwater-trawl surveys were undertaken of the British Columbia herring stocks during their offshore existence. Principal effort was expended on the region off southwest Vancouver Island (Areas 3C-N and 3C-S) and some effort was expended in Juan de Fuca and Georgia straits (Area 4B). Table 3 contains an inventory of the relevant research cruises, and their published reports. Surveys completed in Queen Charlotte Sound (Areas 5A and 5B) and Hecate Strait (Areas 5C and 5D) are not relevant to this study and are not listed.

RESULTS

TAGGING EXPERIMENTS

All analyses indicated a modest migration of cod back and forth between the inshore grounds (Areas 4A and 4B) and the offshore grounds (principally Areas 3B and 3C-N) (Westrheim 1982, 1985a, b)

With respect to MSAs 19 and 20, Westrheim (1982) deduced, from tag returns and landings, that cod were moving westward, to the offshore grounds, in spring, and eastward, to the inshore grounds, in autumn and winter. Results of later experiments (1978-79) were the same (Westrheim 1985b).

In summary, results of the Canadian and U.S. tagging experiments suggest that the Pacific cod appearing in MSA 19 during August-December were probably inbound from the offshore grounds of Areas 3B, 3C-S, and/or 3C-N.

LANDING STATISTICS

MSA 19

Landings. Pacific cod has been the principal species landed from MSA 19 by on-bottom trawlers since the fishery began, about 1950 (Westrheim 1980; Table 19). The rank-2 species is lingcod (Ophiodon elongatus), which briefly achieved rank-1 status in 1959-60 (Fig. 5). Prior to 1958, annual landings of Pacific cod were negligible (<20 t) to nil (Foucher and Guidici 1985; Table 6). During 1956-73, cod landings fluctuated modestly with zeniths at 193 t (1959), 122 t (965); and 78 t (1969); and corresponding nadirs at 40 t (1961), 30 t (1968), and nil in 1973. After 1973, cod landings rose dramatically to a peak of 957 t in 1981; then declined to 376 t in 1984 (Leaman 1985). Provisional estimate for 1985 is 131 t (J. E. Leaman, pers. comm.).

Seasonally, October-December has been the most important quarter-year for landings -- 53.5% overall, and 43.7-81.9% among 5-year periods during 1956-84 (Table 4). Secondary quarter-years were July-September (21.9%) and January-March (19.0%). July-September landings were a minor component prior to 1974.

Annual records for 1974-84 indicate that October-December maintained its dominant position, except in 1982, and that January-March increased in importance (Fig. 6). The April-June fishery is relatively unimportant -- 25-93 t/annum during 1978-84 (Table 5).

LPUEs and Effort. During 1974-84, October-December records provided a continuous record of LPUE, and hence effort (Fig. 7; Table 5). LPUEs oscillated between 200 and 400 kg/h without trend, and non-sychronously with

landings and effort. Effort and landings were well correlated (R^2 = 0.84), which suggests that the fishery was largely opportunistic. That is, effort rapidly adjusted to abundance of cod. Such an adjustment could be readily made due to the small fishing area, and its close proximity of the two ports of landing -- Victoria and Vancouver.

For both July-September (Fig. 7) and January-March (Fig. 8), effort and landings were also well correlated--R^2 = 0.93 and 0.77, respectively. Presumably, the entire July-March fishery is opportunistic.

The close correlation between effort and landings precluded considering LPUE as an adequate index of abundance. Landings, as the next best index, suggested that abundance (availability?) rose to a peak in 1981, and has subsequently declined at least to the 1974 level.

Other Locations

Inshore. Pacific cod landings varied seasonally from all study areas of Area 4B, except MSA 20 (Table 6). Hence, comparisons of landing statistics were necessarily seasonal as well.

Landings from MSA-19 during July-December were compared with those during the following January-March from MSAs 86 and 80 in Area 4A, and MSAs 18 and 17 in Area 4B (Fig. 9). Landings from MSA 80 during April-June (35%) were omitted, because of the appreciable numbers of cod recovered there which had been tagged in MSAs 17 and 18 during the spawning season, January-March (Westrheim 1982).

The sudden rise in MSA-19 landings after 1973 was not accompanied by a coresponding drop in landings from MSAs 86, 80, 18, or 17. However, a faint reciprocal relationship is evident between MSA 19 landings and those of MSAs 86, 80, and 18 from 1977-78 through 1980-81.

Offshore. April-September was the principal time of Pacific cod landings from Areas 3C-N, 3C-S, and 3B, except for Amphitrite Bank (Fig. 10), the principal spawning ground for cod in Area 3C-N (Westrheim and Foucher 1985a). Pacific cod landings from Area 3D were small, and hence not included in this analysis.

April-September cod landings from Area 3C-S vary directly with those from MSA 19 during July-December, at least during 1975-79 (Fig. 10). However, a reciprocal relationship is evident for 1980-82. The sudden increase in cod production was accompanied by a similar increase in production of lingcod and petrale sole (Eopsetta jordani), albeit only one year for the latter (Fig. 11). All three species are established herring predators (Westrheim and Harling 1983; Cass et al. 1984).

Neither the April-September landings from Areas 3C-N or 3B, nor the January-March (following year) landings from Amphitrite Bank (Area 3C-N) reflect the July-December landings from MSA 19. The sharp decline in landings from Amphitrite Bank after 1977, reflect, for the most part, the effect of various conservation regulations.

Summary

January-March cod landings from inshore MSAs did not reflect, negatively or positively, the sudden rise in July-December landings from MSA 19 after 1973. However, there was a brief period (1977-1978 through 1980-81) when a modest reciprocal relationship was evident between the MSA 19 landing records and those from MSAs 86, 80, and 18.

In contrast, among the offshore areas, April-September landings from Area 3C-S also rose abruptly in 1975, and remained "substantial" through 1979. However, a reciprocal relationship was evident during 1980-82. Landing records from the other offshore areas, including the principal spawning ground (Amphitrite Bank), did not reflect the records of MSA 19.

AGE-FREQUENCIES

MSA 19

During 1974-84, age-frequency time series were fairly complete for July-September, October-December, and January-March (Fig. 12). Prior to 1974, intermittent records were available for 1959-70 (Fig. 13).

For July-September (1974, 1976-81, 1983), age-2 cod predominated in 1977, 1979-81, and 1983; age-3 cod predominated in 1976 and 1978; and ages 3 and 4 predominated in 1974 (Fig. 12). For October-December (1975-84), age-2 cod predominated during 1975-81, while age-1 cod predominated during 1982-85. Notably, age-1 cod were also reasonably prominent (30%) during 1978-80. The 1973, 1975, and 1979 year-classes appear to be relatively strong in July-September and October-December. During October-December additional "strong" year-classes might be 1971, 1977, 1978, and 1981.

For January-March (1978-83), age-2[1] cod predominated during 1979-81 and 1983; and age-3[2] cod in 1978 and 1982 (Fig. 12). The 1975 and 1979 year-classes appear to be relatively strong, as they were during July-September and October-December. The 1973 year-class would not be detectable in the January-March 1978-83 time series.

During 1959-70, when cod abundance was modest, scattered records (1959-61, 1964-65, 1970) indicated that age-2 cod predominated in the landings during July-September 1961, and October-December 1960, 1964-65, and 1970 (Fig. 13). Age-3 cod predominated during 1959, and age-4 cod during 1960. Presumably, the 1956 year-class was relatively strong.

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[1]Equivalent to age-1 cod during the preceding year. Birthdate is, arbitrarily, January 1, for all groundfish aged at the Pacific Biological Station (Chilton and Beamish 1982).

[2]Equivalent to age-2 during the preceding year.

Comparisons

January-March. Nineteen comparisons were made of the MSA-19 age-frequencies for October-December with those of nearby locations for the following January-March--3 with MSA 86; 7 with MSA 80; 1 with MSA 18, 1 each with MSA 17-N; and 7 with Amphitrite Bank (Area 3C-N) (Table 7). All but four comparisons indicated independence ($P<.01$). "Similarities" were indicated for one test each with MSA 80 (1982-83; $P>.20$) and MSA 17-N (1978-79, $P>.05$), and two tests with Amphitrite Bank (1970-72; $P>.20$; 1976-77; $P>.50$). These few "similarities" were deemed chance occurrences based on the significant values of the cumulative Chi-squares ($P<.01$).

Five comparisons of age-frequencies among MSAs other than 19, during January-March, yielded one "similarity" (80 vs 18, 1979; $P>.10$). This "similarity" was deemed to be due to chance.

April-June and July-September. Thirty-four comparisons were made of age-frequencies among Areas 3C-N (Big Bank), 3C-S, and 3B--19 for April-June, and 10 for July-September (Table 8). For April-June, 13 of the 19 tests indicated independence--5 of 6 for 3C-N/3C-S, 5 of 7 for 3C-N/3B, and 4 of 6 for 3C-S/3B. Cumulative Chi-square values were significantly large ($P<.01$) in each test. For July-September, the results differed. Six of 10 tests indicated independence--3 of 3 for 3C-N/3C-S, 2 of 6 for 3C-N/3B, and 1 of 2 for 3C-S/3B. However cumulative Chi-square values were significantly large ($P<.01$) in all three tests.

Summary. In general, age-frequencies of Pacific cod were significantly different among locations, but determining the cause(s) is beyond the scope of this study. However, it is evident that stock delineation is not possible with the present data set.

GONAD CONDITION

Gonad condition was only of interest with respect to Pacific cod caught in MSA 19. Spawning season has been generally established to be January-March for both the offshore (Westrheim 1977) and inshore (Ketchen 1961; Bargmann 1980; Karp 1982) areas adjacent to MSA 19.

During 1978-84, 4,055 Pacific cod landed from MSA 19 were examined for gonad condition -- 1,991 males and 2,064 females (Tables 9 and 10). Predominant gonad conditions were immature and resting for both sexes, regardless of sampling month. Evidently, Pacific cod were not congregating in MSA 19 to spawn, nor did many mature cod remain in MSA 19 after December.

DIET

MSA 19

During 1970-84, general comments on stomach contents were reported for 68 samples of Pacific cod landed from MSA 19 (Table 11). Principal species reported were Pacific herring (Clupea harengus pallasi) and walleye pollock (Theragra chalcogramma). Herring were reported in one or more samples in all years for Quarter I (1978-83) and Quarter II (1979-80); 80% in Quarter III (1974-83); and 70% in Quarter IV (1970; 1976-84). No herring incidence was recorded from samples in 1970 (Quarter IV), 1974 (Quarter III), or 1975 (Quarter II).

Evidently, herring was the principal prey of Pacific cod during most of the study period.

Area 3C-N

During 1950-80, principal stomach contents of Pacific cod landed in British Columbia from Area 3C-N were sandlance (59.0% of all samples), herring (43.4%), "shrimp" (19.3%), and "other" (24.0%) -- N=83 samples (Westrheim and Harling 1983). Among quarter-years, herring incidence was 28, 36, 75, and 100%, respectively, for Quarters I-IV -- N=25, 39, 16, and 3.

Area 3C-S

Only seven samples of Pacific cod were collected from Canadian landings originating from Area 3C-S -- one in 1976, five in 1977, and one in 1979. Stomach contents were noted for four samples, and herring was prominent in all of these. Following are the records:

Year	Landing date	Depth (fath.)	Sampler's comments
1976	Aug. 10	85-110	None
1977	Jul. 19	74-110	None
	Aug. 02	72-110	Large herring
	18	72-95	None
	Sep. 06	75-90	Heavy on herring
	14	110-115	Heavy on herring
1979	May 22	72-91	Herring; proriger[a]; squat lobster[b]

[a] Sebastes: proriger.

[b] Munidae.

Summary

Herring appear to be the principal prey of Pacific cod in MSA 19, Area 3C-N, and possibly Area 3C-S.

HERRING SURVEYS

Results of the herring surveys in Areas 3C-N, 3C-S, and Juan de Fuca Strait (Table 3) follow, in abbreviated form.

Area 3C-N

Surveys confirmed the well-known fact that herring are regular residents of the offshore grounds of Area 3C-N.

Area 3C-S

Mid-water trawling took place during 1968-70, 1972-77, and 1979-81 in Area 3C-S. No herring were caught until 1973, when "substantial" quantities were caught in each of the two hauls completed. Subsequently, herring were caught in all the remaining surveys. Presumably, herring are not regular inhabitants of Area 3C-S, but did take up residence during 1973-81.

Juan de Fuca Strait (MSAs 19, 20, 80, 86, 89)

Echo-sounder/midwater-trawl surveys were completed monthly during July-December 1971, as well as in November 1980 and March 1981. Substantial concentrations of herring were only found in relatively shallow water (<70 fath; 128 m), and largely along the north shore of the Strait -- particularly in MSA 19 off Victoria. No juvenile herring were caught in July; abundance peaked in November, and declined sharply in December. During August-December the schools moved westward through MSAs 19 and 20. Abundance of adult herring was relatively low throughout the July-December survey; peaked in July and September; and declined sharply in December. The investigators hypothesized a westward migration of juvenile herring and an eastward migration of adult herring during July-December.

During November 1980, the five trawl hauls in MSA 19, yielded large catches of adult herring off Victoria (MSA 19), in 50 fath (92 m).

During March 1981, the three hauls in western MSA 20 yielded small catches of herring primarily adults.

A cursory review of the relevant herring survey reports, revealed two facts important to the current Pacific cod study. First, that herring are probably not regular inhabitants of Area 3C-S. Second, that herring were

found to concentrate in Juan de Fuca Strait, at least the Canadian portion thereof, during August-December 1971.

SUMMARY AND CONCLUSIONS

During 1974-84, Pacific cod abundance rose dramatically in the Canadian portion of eastern Juan de Fuca Strait (MSA 19). Prior to 1974, annual landings rarely exceeded 100 t. After 1973, landings rose abruptly to 957 t in 1981; then declined to 376 t in 1984. Provisional estimate for 1985 is 131 t.

Results of Canadian and U.S. tagging experiments indicated a modest quantity of cod passing through Juan de Fuca Strait in both directions. In general cod were outbound in spring, and inbound in fall and winter.

Close correlation of effort and landings precluded use of LPUEs to compare relative abundance among locations. Trends in landings from MSA 19 during October-December exhibited little relationship with those of nearby MSAs, during the following January-March, except for a brief period (1977-78 through 1980-81) when a modest reciprocal relationship was evident with MSAs 86, 80, and 18. With respect to offshore areas, landings from Area 3C-S during the preceding April-September exhibited a close correlation with MSA 19, except for a reciprocal relationship during 1980-82. No relationship was evident between MSA 19 landing trends and those for Areas 3C-N or 3B.

Age-2 cod predominated in the landings from MSA 19, except those in October-December 1982-84, when age-1 cod predominated. The latter exception was due to a reduction in minimum size by the processors to increase the supply of cod fillets. Overall, Pacific cod abundance has been declining in British Columbia waters since 1979. Chi-square tests of independence suggested heterogeneous age-frequencies among catch locations.

All mature cod landed from MSA 19 were in pre-spawning or post-spawning condition.

Principal stomach contents of cod landed from MSA 19 were herring, often noted as "large".

Results of herring surveys in Juan de Fuca Strait indicated a westward movement of juvenile herring and an eastward movement of adult herring during July-December. Furthermore, offshore herring surveys indicated an anomalous appearance of herring in Area 3C-S during 1973-81.

Coincidentally, a "new" trawl fishery developed in 1975 on Cape Flattery Spit (Area 3C-S) which landed Pacific cod, lingcod, and petrale sole -- all established herring predators. Cod production has followed a similar trend to that of MSA 19.

On the basis of the available evidence, we conclude that the anomalous cod aggregation in MSA 19 originated from offshore grounds, and that they were attracted to MSA 19 by an anomalous aggregation of adult herring. These herring may well have migrated from Cape Flattery Spit (Area 3C-S), an anomalous summering ground, and stopped short of their customary pre-spawning staging area, perhaps in MSA 18. Interestingly, Cape Flattery Spit lies approximately 33 nautical miles south of Big Bank (the major "summering" area for herring and cod), and MSA 19 (Constance Bank) is approximately 32 nautical miles from MSA 18 (Swanson Channel), a pre-spawning staging area.

This hypothesis may also explain the anomalous lingcod fishery in MSA 19 during October-December 1959-60 (Fig. 4). Offshore, Area 3C landings of lingcod were large during 1959-61, while comparable landings of Pacific cod were small (Westrheim and Foucher 1985a; Fig. 3.3.1). Inshore, cod landings were large during 1957-59 from Area 4A, and large during 1957-60 from Area 4B (op. cit.; Fig. 3.2.1).

ACKNOWLEDGMENTS

The authors acknowledge with thanks the help of R. P. Foucher for converting the Pacific cod length-frequencies into age-frequencies. G. G. Bargmann (WDF), C. W. Haegele, Dr. L. J. Richards, and R. W. Tanasichuk reviewed the manuscript, which was substantially improved thereby.

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Table 1. Inteviewed landings (t), effort (h), and LPUE (kg/h), by qualification level, for Pacific cod from MSA 19, October - December, 1974-84.

	Qualification level											
	0%			20%			40%			60%		
Year	Land. (t)	Effort (h)	LPUE (kg/h)	Land. (t)	Effort (h)	LPUE (kg/h)	Land. (t)	Effort (h)	LPUE (kg/h)	Land. (t)	Effort (h)	LPUE (kg/h)
1974	25	122	205	24	114	211	22	97	227	22	97	227
1975	145	428	339	145	425	341	141	413	341	141	413	341
1976	73	199	367	71	166	428	71	166	428	60	152	395
1977	301	830	363	300	830	361	292	787	371	227	559	406
1978	190	799	238	177	652	271	168	550	305	81	310	271
1979	200	1,063	188	197	1,023	193	119	564	211	106	521	203
1980	242	1,026	236	242	1,026	236	224	854	262	199	740	269
1981	380	1,432	265	380	1,432	265	377	1,387	272	309	1,072	288
1982	41	168	244	41	168	244	41	168	244	41	168	244
1983	53	173	306	53	168	315	53	168	315	27	96	281
1984	52	112	464	52	112	464	52	112	464	52	112	464

Table 2. Criteria for condition of Pacific cod gonads[a].

Condition	Testes	Ovary
1. Immature	String-like, translucent	Small, translucent
2. Maturing	Small, some proportionally large convolutions, translucent to white	Small, coloring
3. Mature	Large, convolutions firm, whitening	Large, opaque, creamy, blood vessels prominent
4. Mature	Large, convoluted, white	Large, eggs visible, creamy yellow
5. Mature (ripe)	Large, milt running, white	Large, eggs translucent
6. Mature (spent)	Medium, convolutions, flaccid, bloodshot	Medium, flaccid, bloodshot
7. Mature (resting)	Small, convolutions firm, translucent red, or tan	Small, firm, black or grey

[a]Table 12 in Westrheim (1977).

Table 3. Inventory of echo-sounder/midwater-trawl surveys of Pacific herring off southwest British Columbia, by month and location, 1968-81.

Year	Month	Location	Source
1968	Jun-Jul	3C-S/3C-N/3D/4B(20)[a]	Taylor 1969
	Jul-Aug	3C-S/3C-N/3D	
	Sep	3C-S/3C-N	
	Sep-Oct	3C-S/3C-N/4B(20,18,17,13)	
1969	Jun-Jul	3C-S/3C-N	Taylor 1970
	Aug-Sep	3C-S/3C-N	Taylor, Barner, and Miller 1970a
	Oct	3C-S/3C-N	Taylor, Barner, and Miller 1970b
1970	Jan	3C-S/3C-N	Taylor, Barner, and Miller 1970c
	Mar-Apr	3C-S/3C-N	Taylor, Barner, and
	May-Jun	" "	Miller 1970d
1971	Jan-Feb	3C-N/4B(20)	Barner and Taylor 1972
	Mar-Apr	" "	
	Jul	4B(20,19)	Taylor and Barner 1974
	Aug-Sep	"	
	Sep-Oct	"	
	Nov	"	
	Dec	"	
1972	Jan	3C-N	Taylor and Barner 1973
	Mar	"	
	Apr	"	
	Oct-Nov	3C-S/3C-N	" " " "
1973	Jan	3C-N	Barner and Taylor 1974
	Mar	3C-S/3C-N	" " " "
	Oct	3C-S/3C-N	Barner and Taylor 1977
1974	Aug	3C-S/3C-N	Barner and Taylor 1978a
	Oct	" "	
1975	Sep	3C-N	" " " "
	Nov	3C-S/3C-N	
1976	Nov	3C-S/3C-N	Barner and Taylor 1978b
1977	Mar	3C-N	" " " "
	Jun	3C-S/3C-N	
	Sep	" "	
1979	Oct-Nov	3C-S/3C-N	Barner, Taylor Thompson, and Ryan 1980
1980	Sep	3C-S/3C-N	Barner Taylor and Turner 1982a
	Nov	4B(19,18,17,15,13)	Barner, Kieser, and Taylor 1982
	Nov	3C-S/3C-N	Barner, Taylor and Turner 1982b
1981	Mar	3B/3C-S/3C-N/3D/4B(20)	McCarter, Barner, and Taylor 1982
	Sep	3C-S/3C-N	Barner, Taylor, and McCarter 1982

[a]MSAs trawled in Area 4B are in parentheses.

Table 4. Percent total landings of Pacific cod from MSA 19, by quarter-year and 5-year period, 1956-84.

Year	Quarter-year					Landings
	I	II	III	IV	Total	(t)
1956-59	33.1	3.2	0.4	63.3	100.0	281
1960-64	23.8	6.2	5.3	54.8	100.1	341
1965-69	14.4	0.7	3.0	81.9	100.0	298
1970-74	7.6	1.6	20.8	70.0	100.0	250
1975-79	11.2	3.1	26.3	59.3	99.9	2,423
1980-84	24.1	8.2	24.0	43.7	100.0	3,433
Total	19.0	5.6	21.9	53.5	100.0	
Landings (t)	1,335	384	1,541	3,756		7,026

Table 5. Standardized landing statistics for Pacific cod from MSA 19, by quarter-year, 1974-84.

Year	Quarter-year											
	July-September			October-December			January-March			April-June		
Year	Effort[a] (h)	Land.[b] (t)	LPUE[c] (kg/h)	Effort[a] (h)	Land.[b] (t)	LPUE[c] (kg/h)	Effort[a] (h)	Land.[b] (t)	LPUE[c] (kg/h)	Effort[a] (h)	Land.[b] ((t)	LPUE[c] (kg/h)
1974	159	52	327	515	117	227	-	-	-	-	-	-
1975	273	84	308	742	253	341	UNK	57	UNK	-	-	-
1976	582	206	354	322	138	428	UNK	4	UNK	-	-	-
1977	245	100	408	1,040	386	371	UNK	5	UNK	?	1	T
1978	507	173	341	1,102	336	305	333	98	294	136	39	286
1979	251	74	295	1,540	325	211	3394	108	274	106	36	339
1980	815	374	459	1,504	394	262	349	68	195	169	37	219
1981	554	209	377	1,838	500	272	381	200	525	267	48	180
1982	167	31	186	775	189	244	1,078	308	282	853	93	109
1983	530	160	302	851	268	315	601	169	281	?	25	500
1984	100	50	*500	321	149	*464	UNK	86	UNK	UNK	79	-

[a]Effort = (total landings)/LPUE.

[b]Total landings.

[c]40% qualification level.

Table 6. Mean proportions (%) of Pacific cod landed from selected major and minor areas, by quarter-year, 1963-84.

Area		Quarter-year					Mean annual landing	
Major	Minor	I	II	III	IV	Total	(t)	(%)
				Inshore				
4B	All	42	12	12	34	100	812	100
	14	47	14	2	37	100	66	8
	17	78	9	7	13	100	100	12
	18	57	17	4	22	100	223	27
	19	18	6	23	53	100	298	37
	20	25	23	21	21	100	91	11
								(95)
4A	All	52	25	5	18	100	934	100
	80	38	35	8	19	100	559	60
	86	74	9	1	16	100	312	33
								(93)
				Offshore				
3B	All	24	41	22	13	100	643	-
3C-N	All	43	36	16	5	100	2,058	-
	AB[a]	78	20	2	T	100	1,039	-
3C-S	All	5	38	51	6	100	227	-

[a]AB = Amphitrite Bank, 1960-82 (Foucher and Westrheim 1984, Table 2).

Table 7. Chi-square tests of independence[a] among age-frequencies (5) of Pacific cod landed from selected locations in Areas 4A, 4B, and 3C-N during October-December (MSA 19) and the following January-March (all other locations), 1975-85. (Data source: Appendix tables 1 and 2.)

Year	x^2	df	P	Year	x^2	df	P
	MSA 19 vs 86				MSA 19 vs Amphitrite Bank (3C-N)		
1981-82	21.478	2	<.01	1964-65	20.632	2	<.01
1982-83	25.046	2	<.01	1965-66	11.432	2	<.01
1984-85	17.486	2	<.01	1970-71	3.912	3	>.20
				1975-76	24.394	3	<.01
Total	64.010	6	<.01	1976-77	2.120	3	>.50
				1977-78	22.654	2	<.01
	MSA 19 vs 80			1978-79	52.196	3	<.01
1978-79	25.654	3	<.01	Total	137.40	18	<.01
1979-80	78.224	3	<.01				
1980-81	72.688	2	<.01		MSAs 86 vs 80		
1981-82	104.214	2	<.01				
1982-83	2.638	2	>.20	1982	42.412	2	<.01
1983-84	19.998	2	<.01	1983	14.036	2	<.01
1984-85	147.386	2	<.01	1985	82.728	2	<.01
Total	450.802	16	<.01	Total	139.176	6	<.01
	MSAs 19 vs 18				MSAs 80 vs 18		
1978-79	10.378	3	<.02	1979	5.678	3	>.10
	MSAs 19 vs 17-N				MSAs 18 vs 17-N		
1978-79	7.432	3	>.05	1979	24.636	3	<.01

[a]Dixon and Massey (1969, p. 240).

Table 8. Chi-square tests of independence[a] among age-frequencies (5) of Pacific cod landed from selected locations in Areas 4A, 4B, and 3C-N during April-June and July-September 1975-82. (Data source: Appendix tables 3 and 4.)

Year	April-June x^2	df	P	Year	July-September x^2	df	P
	3C-N vs 3C-S				3C-N vs 3C-S		
1975	16.810	2	<.01	1975	12.616	3	<.02
1986	3.014	3	>.30	1977	11.552	3	<.01
1978	18.788	2	<.01	1982	39.120	2	<.01
1979	8.840	3	<.05				
1980	18.066	3	<.01	Total	63.288	8	<.01
1982	10.234	3	<.02				
					3C-N vs 3B		
Total	75.752	16	<.01				
				1975	3.188	2	>.10
	3C-N vs 3B			1976	0.525	3	>.90
				1979	34.815	3	<.01
1975	14.530	3	<.01	1980	0.710	3	>.80
1976	14.624	3	<.01	1981	18.110	3	<.01
1978	11.910	2	<.01				
1979	25.898	3	<.01	Total	57.348	14	<.01
1980	4.694	3	>.10				
1981	7.948	3	<.05		3C-S vs 3B		
1982	2.840	3	>.30				
				1975	4.108	2	>.10
Total	82.444	20	<.10	1978	34.476	2	<.01
	3C-S vs 3B			Total	38.584	4	<.01
1975	4.192	2	>.10				
1976	18.598	2	<.01				
1978	1.752	3	>.50				
1979	64.770	3	<.01				
1980	16.482	3	<.01				
1982	3.352	2	>.10				
Total	109.146	15	<.01				

[a]Dixon and Massey (1969, p. 240)

Table 9. Gonad condition (%) of male Pacific cod landed from MSA 19, by month, 1978-84.

Year	Month	Condition[a] 1	2	3	4	5	6	7	N
1978	January	38	7	12	40	-	-	2	124
	August	4	-	-	-	-	-	96	59
	September	2	-	-	-	-	-	98	50
	November	5	75	18	-	-	-	2	197
	December	43	3	37	17	-	-	-	68
1979	February	2	-	2	30	-	5	61	44
	April	-	-	-	-	-	28	72	74
	October	8	44	4	-	-	-	44	128
	November	13	50	16	2	-	-	19	141
	December	47	15	-	-	-	-	38	68
1980	January	-	9	21	-	-	-	70	57
1981	January	76	-	-	22	-	-	1	55
	August	45	-	-	-	-	-	55	51
	October	50	-	-	-	-	-	50	50
	November	11	79	4	1	-	-	4	124
	December	30	34	33	-	-	-	3	64
1982	January	13	2	4	68	-	-	13	127
	November	39	49	1	-	-	-	11	124
	December	73	23	4	-	--	-	-	102
1983	January	83	1	5	10	-	-	1	94
1984	October	12	74	-	-	-	-	14	190
Total									1,991

[a]1 & 2 = immature; 3 & 4 = maturing; 5 = ripe; 6 = spent; 7 = resting.

Table 10. Gonad condition (%) of female Pacific cod landed from MSA 19, by month, 1978-84.

Year	Month	Condition[a]							N
		1	2	3	4	5	6	7	
1978	January	51	3	11	12	-	-	5	116
	August	4	-	-	-	1	-	93	61
	September	4	-	-	-	-	-	96	70
	November	8	59	2	-	-	-	30	207
	December	58	19	21	2	-	-	-	52
1979	February	-	-	-	18	3	3	76	76
	April	4	-	-	-	-	-	96	46
	October	9	59	-	-	-	-	32	127
	November	12	47	3	-	-	-	38	159
	December	-	38	-	-	-	-	62	52
1980	January	-	26	3	-	-	-	71	63
1981	January	77	11	-	6	-	-	6	65
	August	51	-	-	-	-	-	49	69
	October	80	-	-	-	-	-	20	70
	November	20	73	-	-	-	-	6	116
	December	31	60	4	-	-	-	5	55
1982	January	19	19	48	12	1	-	1	113
	November	42	34	1	1	-	-	23	139
	December	80	12	-	-	-	-	8	101
1983	January	85	4	9	-	-	-	2	98
1984	October	19	65	-	-	-	-	16	209
Total									2,064

[a]1 & 2 = immature; 3 & 4 = maturing; 5 = ripe; 6 = spent; 7 = resting.

Table 11. Incidence of herring, walleye pollock, and "miscellaneous" in the stomachs of Pacific cod landed from MSA 19, by quarter-year, 1970-84.

Year	Quarter	No. of samples	Incidence			No comment
			Herring	Pollock	Misc.	
1970	IV	2	-	-	-	2
1974	III	1	-	-	-	1
1975	III	1	-	1	-	1
1976	III	2	1	-	-	1
	IV	1	-	-	-	1
1977	III	2	2	-	-	-
	IV	12	7	-	1	4
1978	I	2	1	-	-	1
	III	4	4	1	-	-
	IV	5	5	1	1	-
1979	I	1	1	-	-	-
	II	1	1	1	-	-
	III	1	1	-	-	-
	IV	5	5	-	-	-
1980	I	1	1	-	-	-
	II	1	1	-	-	-
	III	5	5	-	2	-
	IV	1	1	-	-	-
1981	I	1	1	1	1	-
	III	3	3	-	2	-
	IV	5	5	-	-	-
1982	I	2	2	1	-	-
	IV	1	-	-	1	-
1983	I	1	1	-	1	-
	III	3	3	3	2	-
	IV	2	2	2	1	-
1984	IV	2	2	-	-	-
Total		68				

Appendix table 1. Age-frequencies (%) of Pacific cod landed from MSA 19[a] during October-December and from MSAs 17-N, 18, 80, and 86 during the following January-March, 1979-85.

Year	Catch location	Age (y) 1	2	3	4	5	6	>6	N[b]
1979	19	-	31.6	46.0	19.3	2.3	0.3	0.5	114.7
	80	0.8	62.3	16.2	15.5	-	2.2	3.0	N.D.[c]
	18	-	47.3	28.0	16.1	7.9	0.5	0.4	60.3
	17-N	-	20.4	61.9	11.8	4.3	0.6	1.1	13.4
1980	19	-	30.9	42.6	16.7	6.3	1.2	2.2	141.5
	80	10.2	80.6	6.2	3.0	-	-	-	N.D.
1981	19	-	29.1	59.1	0.6	9.7	1.5	-	58.6
	80	-	87.9	7.5	4.2	-	0.2	0.2	N.D.
1982	19	-	5.1	86.9	5.7	1.4	0.8	-	342.5
	86	-	30.0	64.8	3.5	0.3	1.3	0.1	N.D.
	80	-	75.9	22.9	-	0.5	-	0.	N.D.
1983	19	-	66.3	8.9	22.2	1.9	0.2	0.6	123.1
	86	-	61.3	32.6	4.0	1.3	0.6	0.2	N.D.
	80	4.6	61.8	16.5	10.2	4.5	2.0	0.4	N.D.
1984	19	-	53.2	33.2	7.3	5.9	T	0.5	155.8
	80	-	82.6	11.3	4.3	1.4	0.4	-	N.D.
1985	19	-	82.7	12.5	3.7	1.1	-	-	57.5
	86	-	57.3	38.0	2.7	2.0	-	-	N.D.
	80	-	-	96.3	2.4	0.7	-	0.4	N.D.

[a] Projected to following January-March; age 2 to age 3, etc.
[b] N=thousands of fish landed.
[c] N.D.=not determined.

Appendix table 2. Age-frequencies (%) of Pacific cod landed from MSA 19 during October-December[a] and from Amphitrite Bank (3C-N) during the following January-March, 1965-66, 1971, 1976-79, and 1982.

Year	Catch location	Age (y) 1	2	3	4	5	6	>6	N[b]
1965	19	-	4.8	83.8	9.1	1.7	0.6	-	19.8
	3C-N	-	-	61.1	27.4	8.0	2.8	0.7	74.1
1966	19	-	0.3	89.4	8.2	1.4	0.6	-	36.7
	3C-N	-	6.9	63.9	21.1	7.4	0.2	0.5	208.7
1971	19	-	10.1	69.2	14.0	5.8	1.0	-	16.8
	3C-N	-	16.7	56.4	16.6	7.1	1.7	1.5	329.5
1976	19	-	-	67.4	8.7	12.4	9.2	2.3	47.3
	3C-N	-	2.0	48.8	34.9	12.1	1.3	1.0	655.0
1977	19	-	1.7	50.90	34.8	10.1	1.2	2.2	39.8
	3C-N	-	7.4	36.6	35.6	14.3	4.5	1.7	454.8
1978	19	-	4.3	77.4	8.9	7.4	1.3	0.7	197.7
	3C-N	-	0.4	49.5	27.7	16.9	1.0	4.5	310.4
1979	19	-	31.6	46.0	19.3	2.3	0.3	0.5	114.7
	3C-N	-	3.4	30.1	38.9	21.1	1.6	5.0	88.2
1982	19	-	5.1	87.0	5.7	1.4	0.8	-	342.5
	3C-N	-	4.4	42.6	32.1	13.7	4.4	2.9	247.6

[a] Projected to the following January-March: age 2 to age 3, etc.
[b] N=thousands of fish landed.

Appendix table 3. Age-frequencies (%) of Pacific cod landed from MSA 19 during October-December and from Areas 3B, 3C-S, and 3C-N (Big Bank) during the preceding April-June 1975-82.

Year	Catch location	Age (y)							N[a]
		1	2	3	4	5	6	>6	
1975	19	-	67.4	8.7	12.4	9.2	1.3	1.0	47.3
	3C-N	-	16.2	76.02	3.1	2.9	1.2	0.1	163.7
	3C-S	-	42.6	51.8	2.8	2.4	0.3	-	N.D.[b]
	3B	-	35.5	50.6	7.5	4.5	1.5	0.4	N.D.
1976	19	1.7	50.0	34.8	10.1	1.2	2.1	0.1	39.8
	3C-N	-	22.4	51.9	18.3	6.0	0.6	0.8	176.7
	3C-S	-	18.4	55.8	22.9	1.6	1.5	-	N.D.
	3B	-	44.5	45.2	8.3	1.8	-	0.2	N.D.
1977	19	4.3	77.4	8.9	7.4	1.3	0.6	0.1	197.7
	3C-N	-	23.6	34.4	27.9	10.5	2.0	1.6	122.5
1978	19	31.6	46.0	19.3	2.3	0.3	0.3	0.2	114.7
	3C-N	-	1.5	72.5	24.5	1.5	-	-	110.3
	3C-S	-	16.3	73.1	5.5	3.4	1.7	-	N.D.
	3B	-	10.2	77.9	5.3	6.2	0.4	-	N.D.
1979	19	30.9	42.6	16.7	6.3	1.2	1.2	1.0	141.5
	3C-N	-	45.2	30.2	15.3	8.1	0.6	0.6	130.0
	3C-S	-	61.0	30.3	6.3	1.9	-	0.5	N.D.
	3B	-	21.1	19.3	40.3	16.0	1.3	2.0	N.D.
1980	19	29.1	59.1	0.6	9.7	1.5	-	-	58.6
	3C-N	-	44.1	19.8	20.8	12.2	3.1	-	75.5
	3C-S	-	18.2	20.4	29.7	28.4	0.7	2.6	N.D.
	3B	-	34.1	32.8	18.0	8.5	3.5	3.1	N.D.
1981	19	5.1	87.0	5.7	1.4	0.8	-	-	342.5
	3C-N	-	13.2	76.1	5.9	0.2	3.2	1.0	22.7
	3B	-	24.4	57.4	10.8	3.4	3.3	0.7	N.D.
1982	19	66.3	8.9	22.2	1.9	0.2	0.3	0.3	123.1
	3C-N	-	8.6	62.4	22.6	3.8	0.5	1.1	16.78
	3C-S	-	21.8	62.9	10.8	3.4	1.1	-	N.D.
	3B	-	12.3	68.3	15.4	3.4	-	0.6	N.D.

[a] N=thousands of fish landed.
[b] N.D.=not determined.

Appendix table 4. Age-frequencies (%) of Pacific cod landed from MSA 19 during October-December and from Areas 3B, 3C-S, and 3C-N (Big Bank), during the preceding July-September, 1975-82.

Year	Catch location	Age (y) 1	2	3	4	5	6	>6	N[a]
1975	19	-	67.4	8.7	12.4	9.2	1.3	1.0	47.3
	3C-N	-	45.0	33.0	10.3	2.3	2.1	0.3	116.3
	3C-S	-	33.0	58.0	5.2	3.0	0.8	-	N.D.[b]
	3B	-	46.3	44.2	6.9	2.1	0.2	0.3	N.D.
1976	19	1.7	50.0	34.8	10.1	1.2	2.1	0.1	39.8
	3C-N	-	29.5	48.1	17.1	4.3	0.5	0.5	191.6
	3B	1.7	24.2	52.4	17.4	4.0	-	0.3	N.D.
1977	19	4.3	77.4	8.9	7.4	1.3	0.6	0.1	197.7
	3C-N	-	37.1	41.4	18.2	0.7	2.6	-	84.7
	3C-S	-	49.9	20.7	20.4	7.4	1.4	0.2	N.D.
1978	19	31.6	46.0	19.3	2.2	0.3	0.3	0.2	114.7
	3C-S	-	49.0	35.2	12.7	1.0	2.1	-	N.D.
	3B	-	14.2	75.0	5.5	5.3	-	-	N.D.
1979	19	30.9	42.6	16.7	6.3	1.2	1.2	1.0	141.5
	3C-N	0.4	36.9	35.5	18.4	6.80	2.0	0.4	125.0
	3B	-	78.3	12.0	5.4	3.3	1.0	-	N.D.
1980	19	29.1	59.1	0.6	9.7	1.5	-	-	58.6
	3C-N	7.1	35.4	31.6	14.5	9.7	1.7	-	49.0
	3B	-	42.7	29.7	13.0	8.9	3.4	2.3	N.D.
1981	19	5.1	86.9	5.7	1.4	0.8	-	-	342.5
	3C-N	8.3	55.3	14.5	15.4	5.3	0.4	0.8	30.4
	3B	-	82.9	15.2	1.9	-	-	-	N.D.
1982	19	66.3	8.9	22.2	1.9	0.2	0.3	0.3	123.1
	3C-N	-	86.1	6.0	7.9	-	-	-	37.7
	3C-S	-	45.9	40.0	9.1	3.4	1.2	0.4	N.D.

[a] N=thousands of fish landed.
[b] N.D.=not determined.

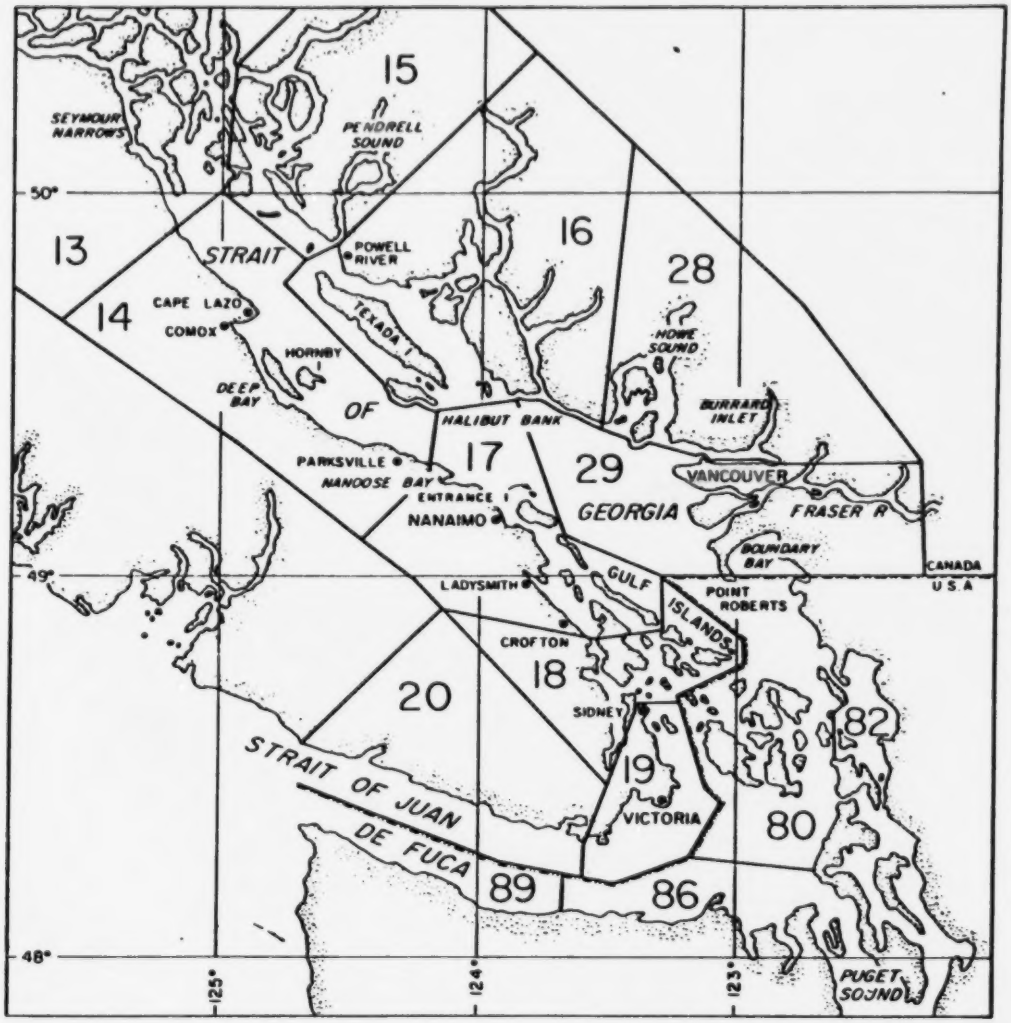


Fig. 1. Minor statistical areas (MSAs) in Area 4A and 4B.

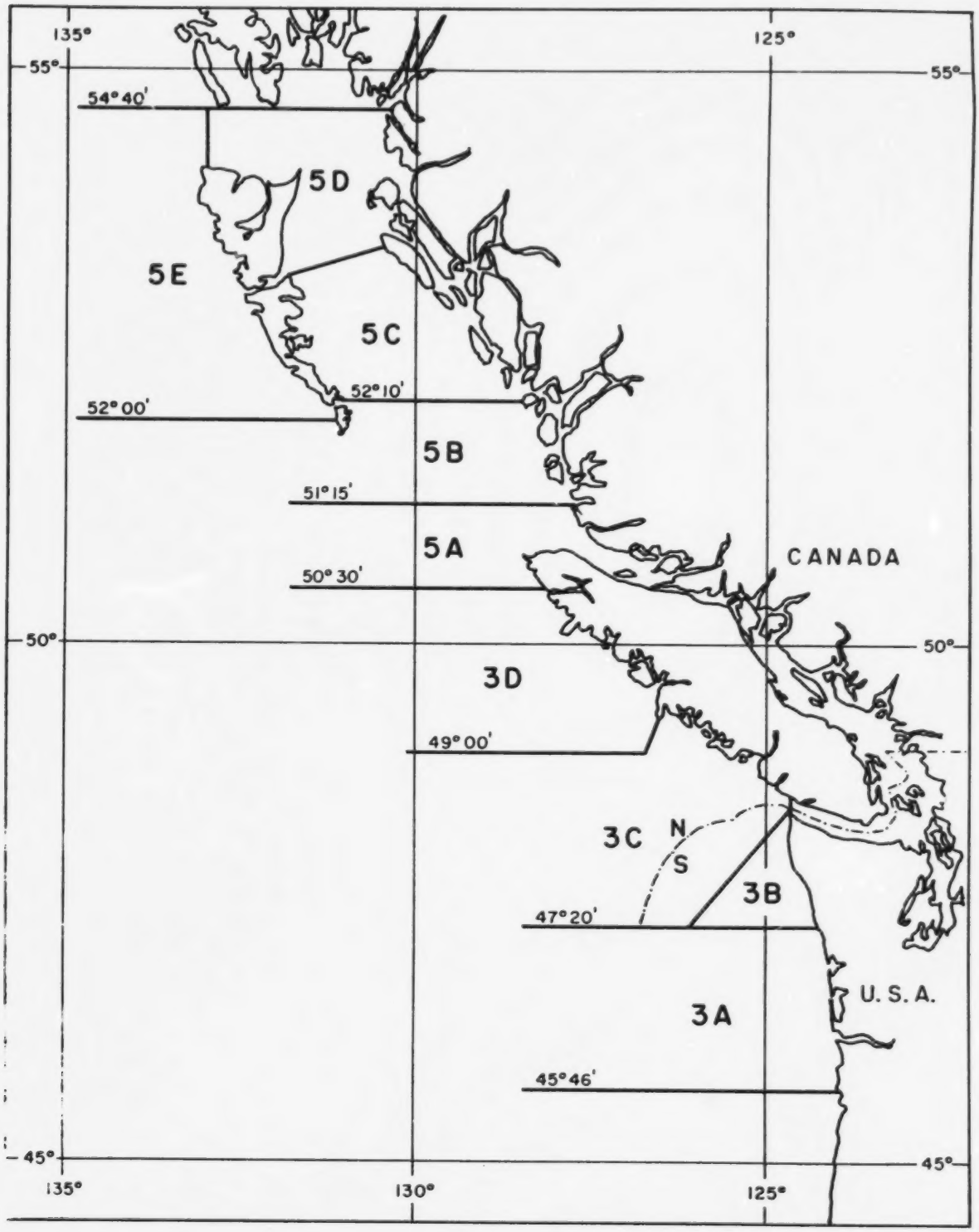


Fig. 2. Major statistical areas off the coasts of British Columbia and Washington State.

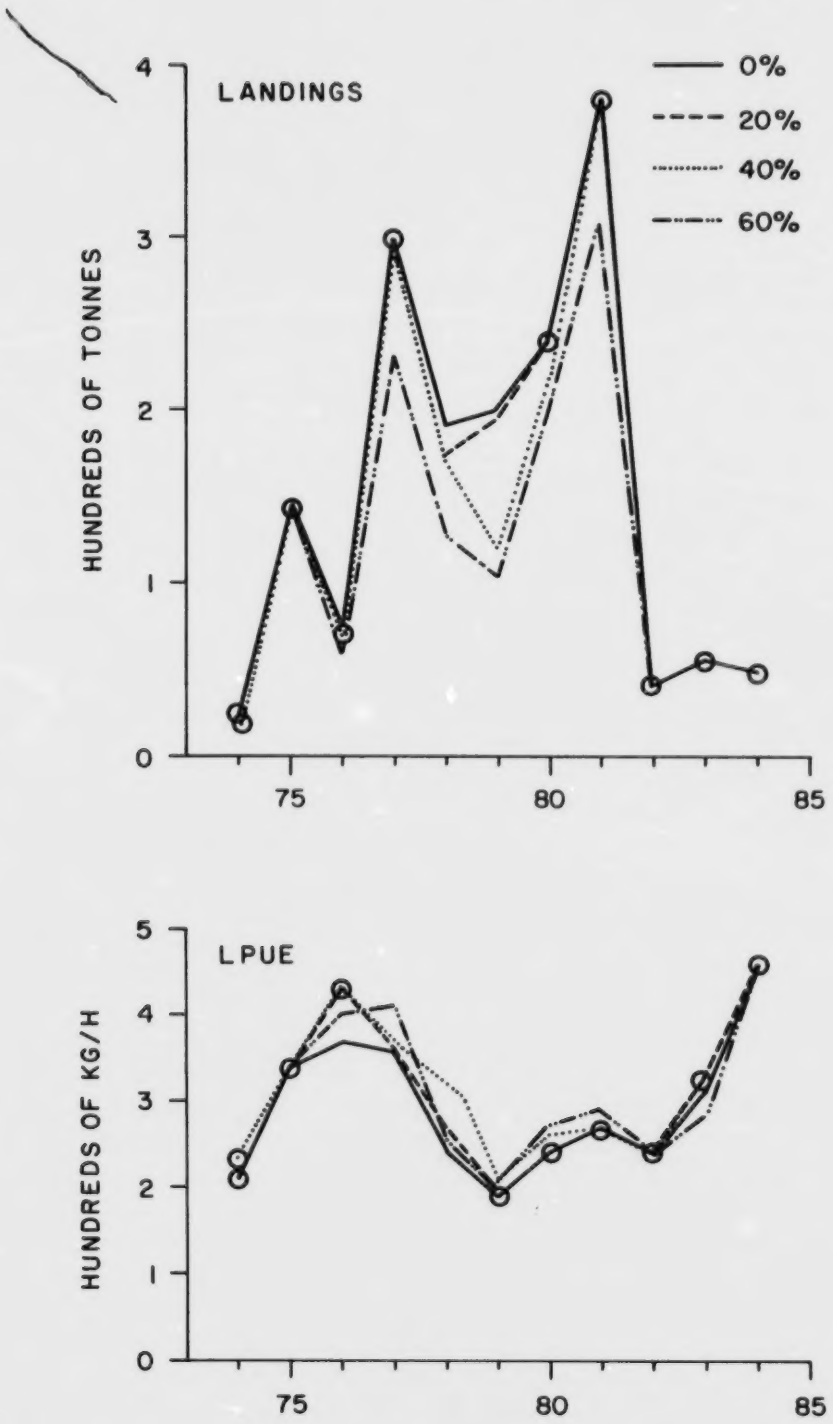


Fig. 3. Interviewed landings (t) and LPUEs (kg/h), by qualification level, from MSA 19, October-December 1974-84.

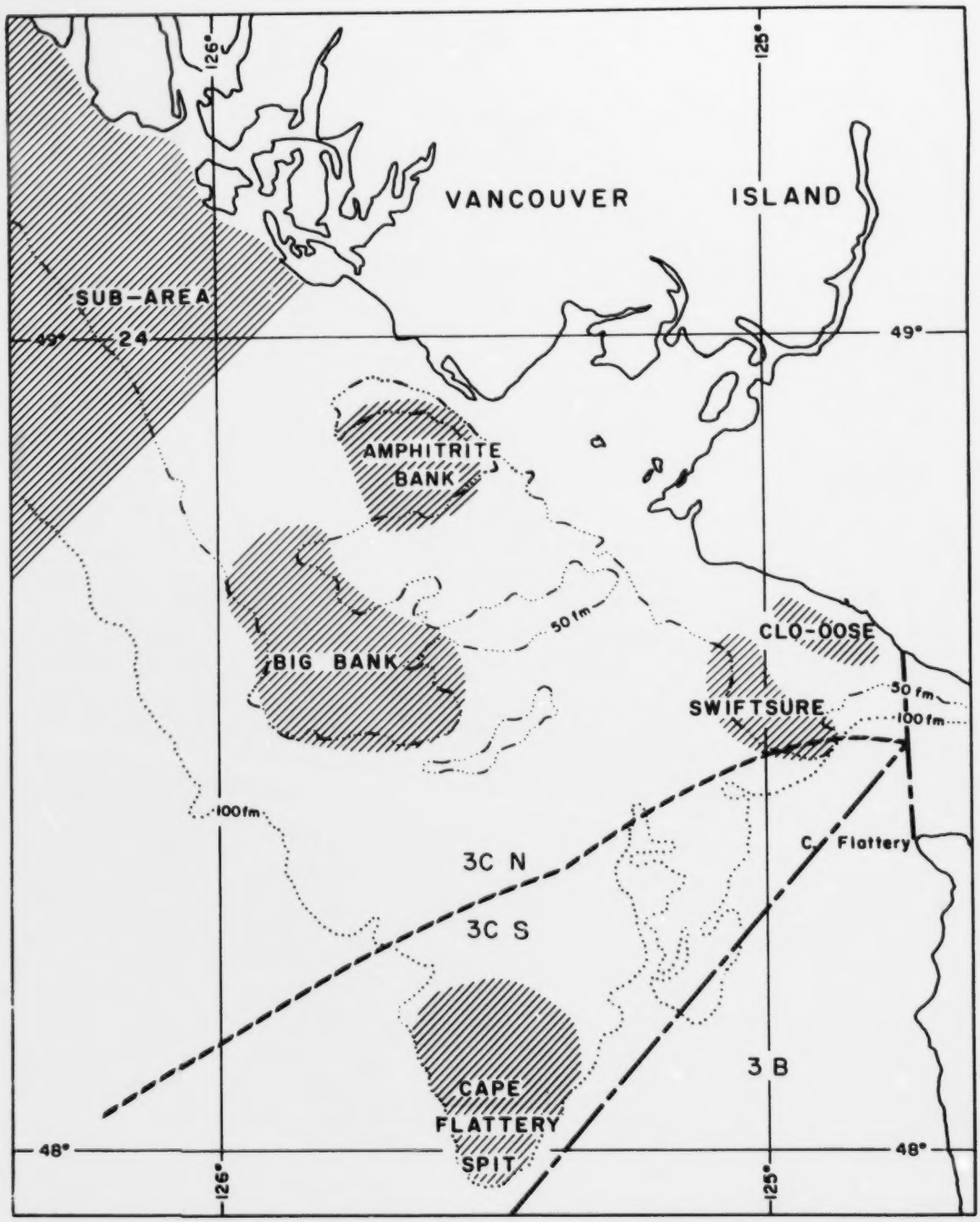


Fig. 4. Important trawling grounds in Area 3C-N and 3C-S.

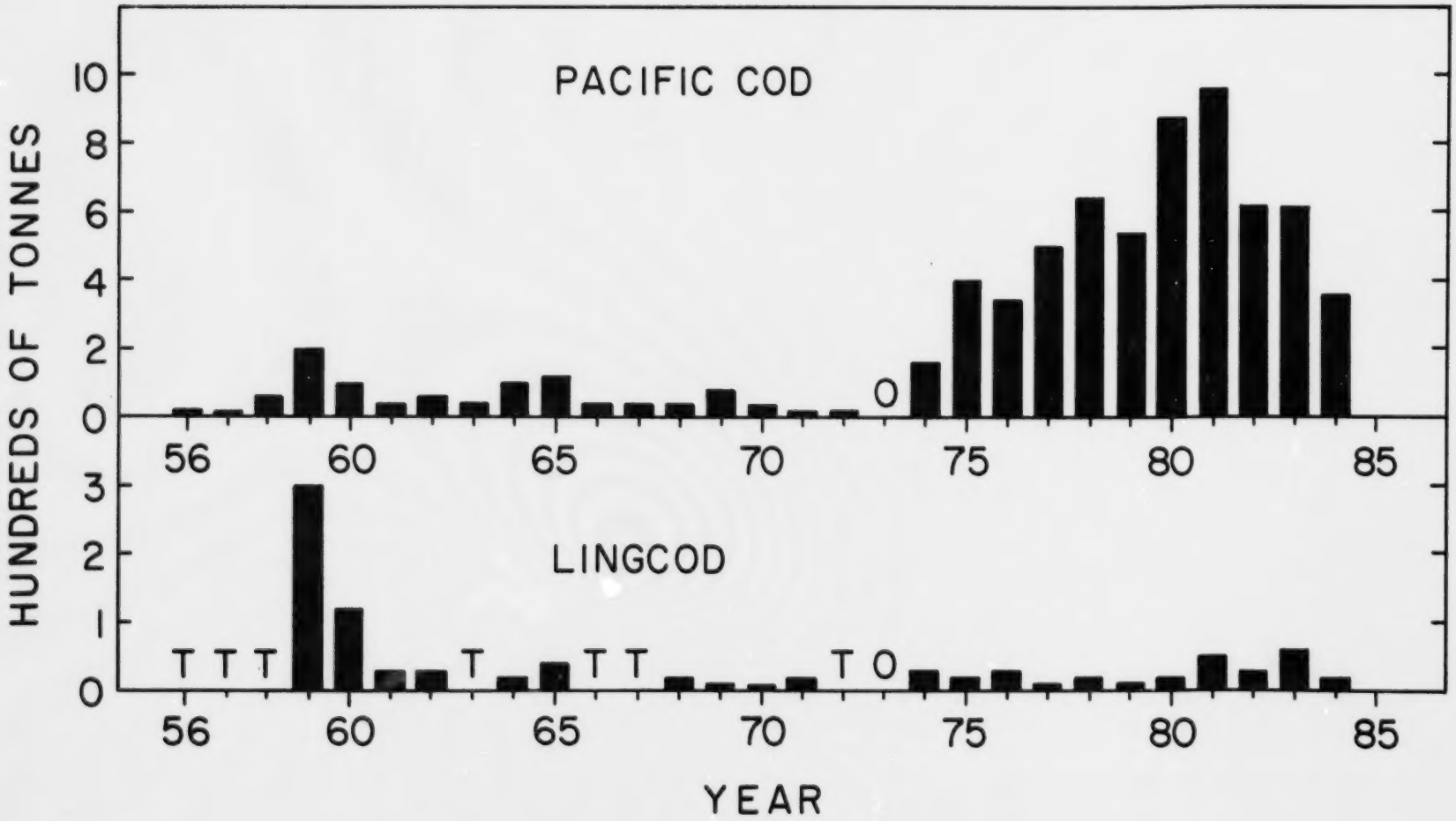


Fig. 5. Annual landings of Pacific cod and lingcod from MSA 19, 1956-84.

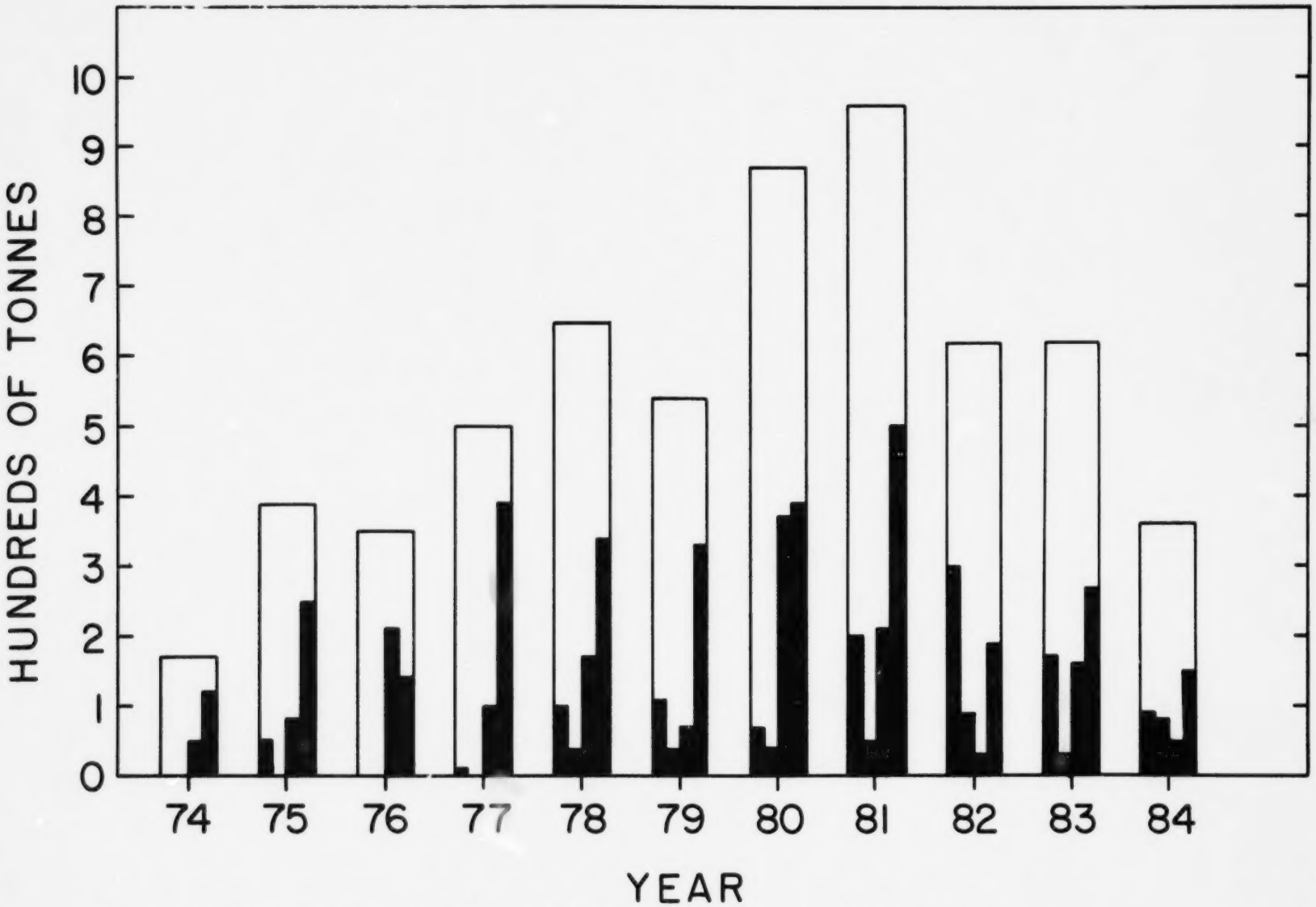


Fig. 6. Pacific cod landings (t) from MSA 19, by quarter-year, 1974-84.

Fig. 7. Standardized landing statistics for Pacific cod from MSA 19, July-September and October-December 1974-84. (Shaded area = interviewed landings.)

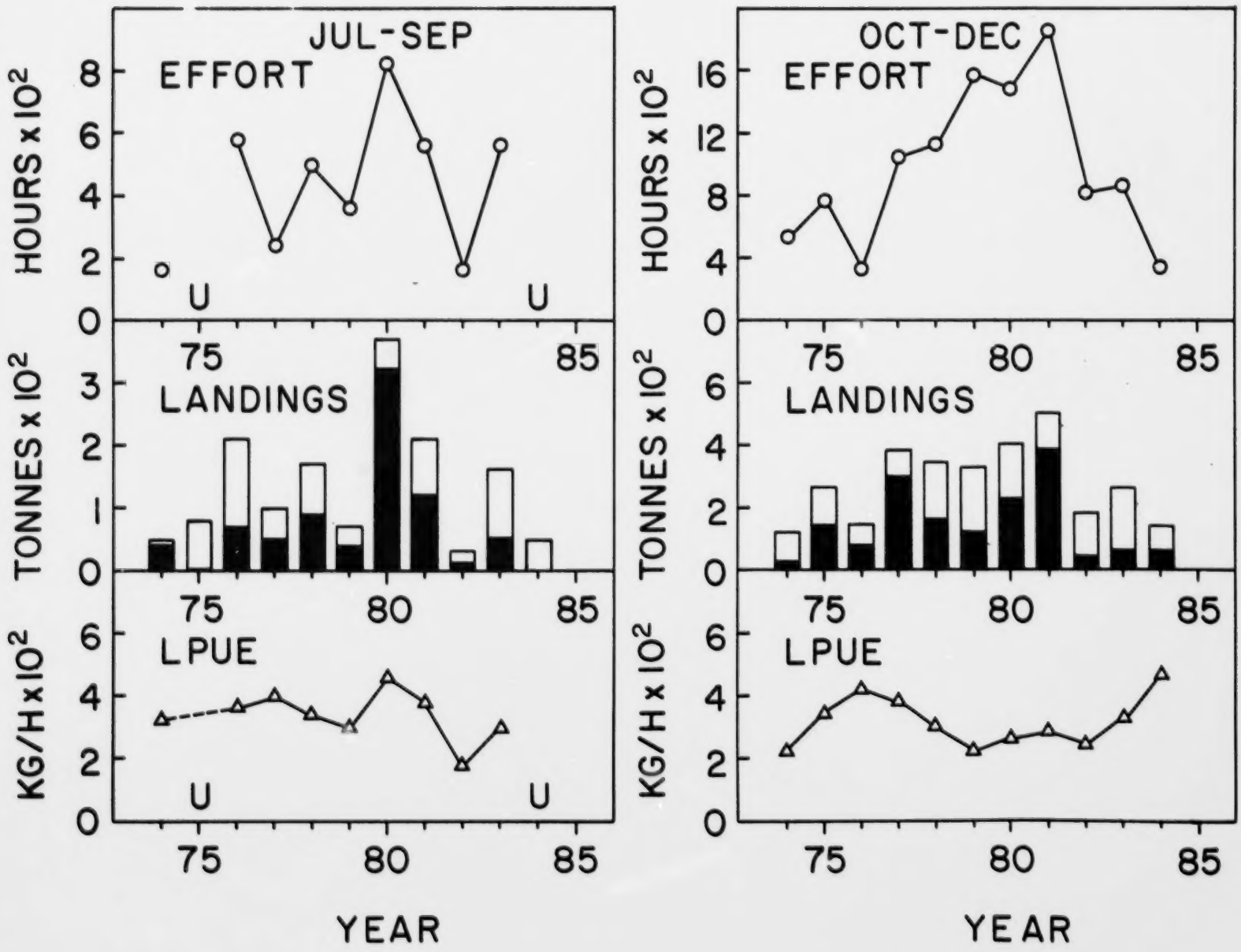

JUL-SEP
EFFORT
HOURS x 10²
LANDINGS
TONNES x 10²
LPUE
KG/H x 10²
U
U
OCT-DEC
EFFORT
HOURS x 10²
LANDINGS
TONNES x 10²
LPUE
KG/H x 10²
75
80
85
YEAR

Fig. 8. Standardized landing statistics for Pacific cod from MSA 19, January-March and April-June 1974-84. (Shaded areas = interviewed landings.)

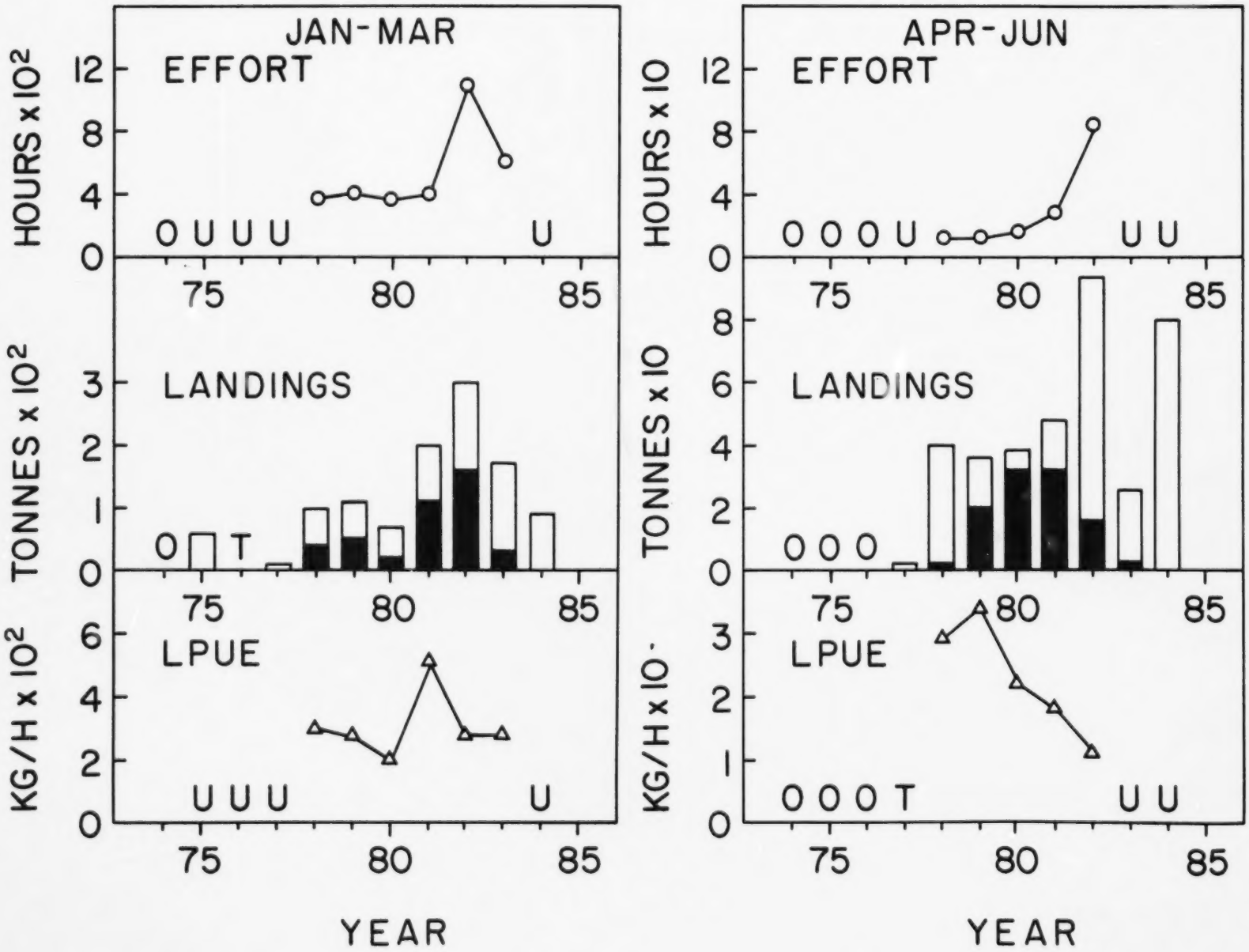

JAN-MAR
APR-JUN
EFFORT
HOURS x 10²
HOURS x 10
LANDINGS
TONNES x 10²
TONNES x 10
LPUE
KG/H x 10²
KG/H x 10
O U U U
U
O O O U
U U
O T
O O O
U U U
O O O T
75
80
85
YEAR

Fig. 9. Pacific cod landings (t) from MSA 19, during July-December 1962-84, and MSAs 86, 80, 18, and 17 during January-March 1963-84.

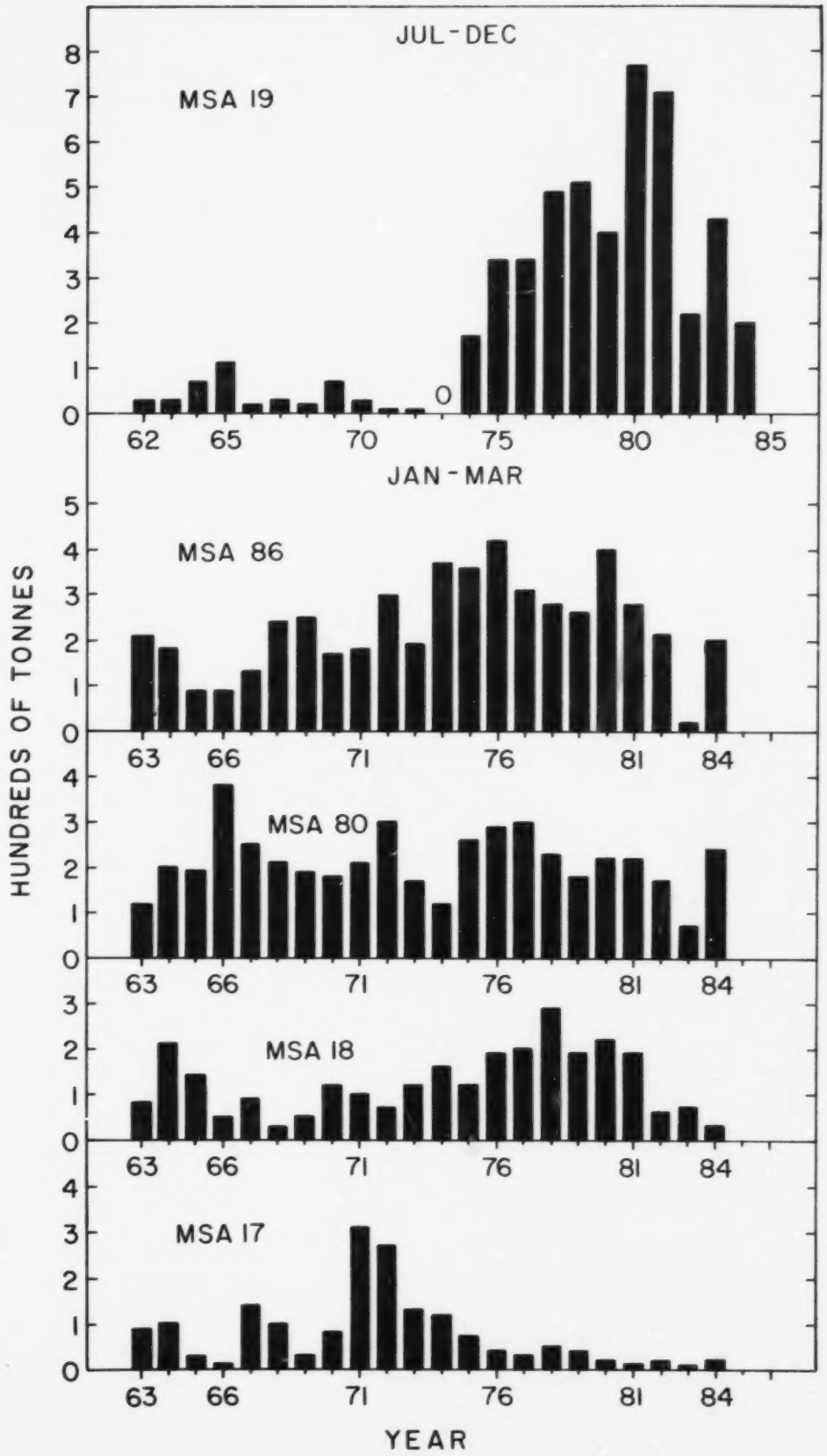
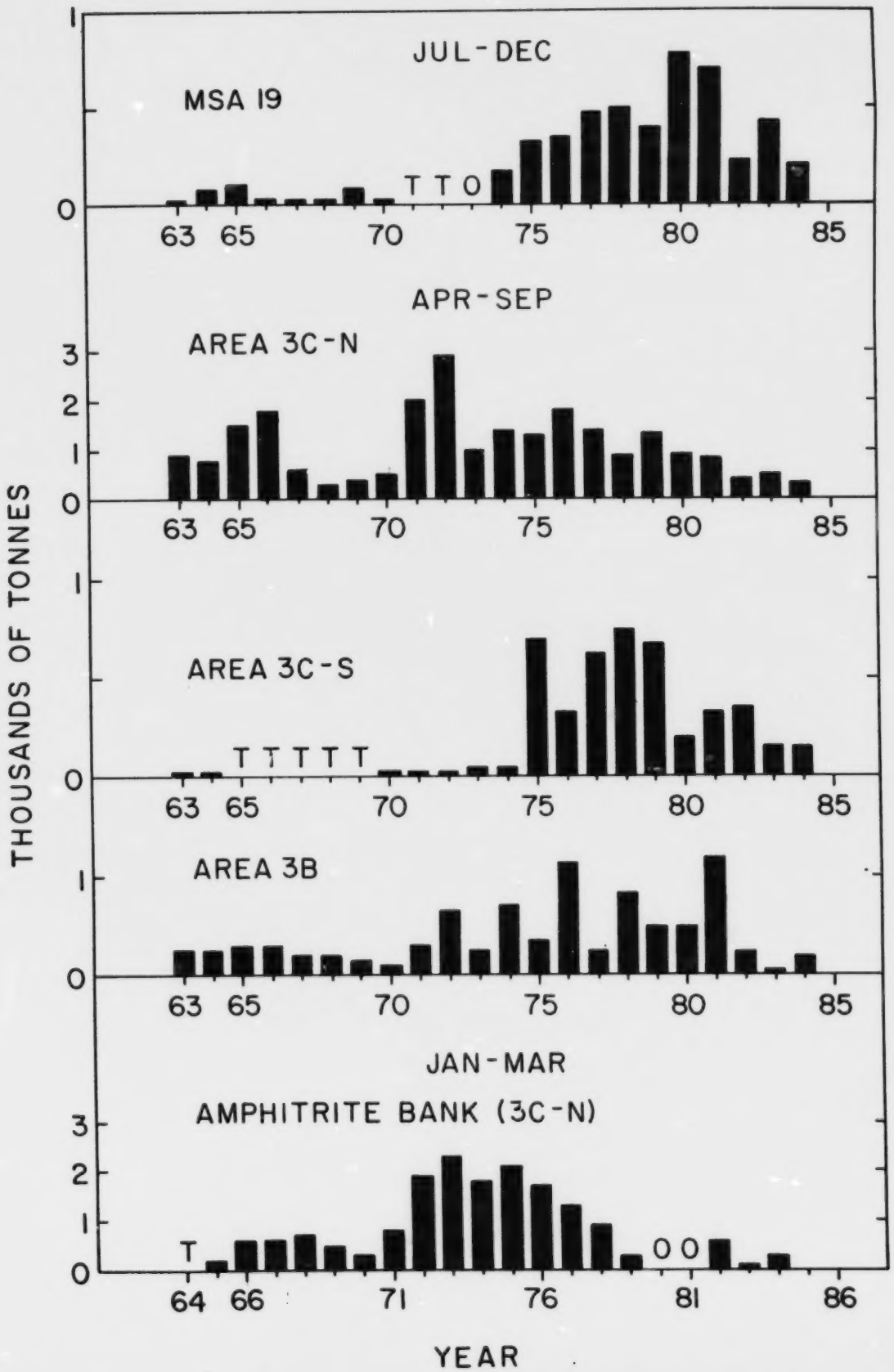

JUL-DEC
MSA 19
JAN-MAR
MSA 86
MSA 80
MSA 18
MSA 17
HUNDREDS OF TONNES
YEAR
0
1
2
3
4
5
6
7
8
62
63
65
66
70
71
75
76
80
81
84
85

Fig. 10. Pacific cod landings (t) from MSA 19, during July-December 1963-84, MSAs 3C-N, 3C-S, and 3B during April-September 1963-84, and Amphitrite Bank (3C-N) during January-March 1964-84.


JUL-DEC
MSA 19
T T O
APR-SEP
AREA 3C-N
AREA 3C-S
T T T T T
AREA 3B
JAN-MAR
AMPHITRITE BANK (3C-N)
T
O O
THOUSANDS OF TONNES
YEAR
63 65 70 75 80 85
64 66 71 76 81 86
0 1
0 1 2 3

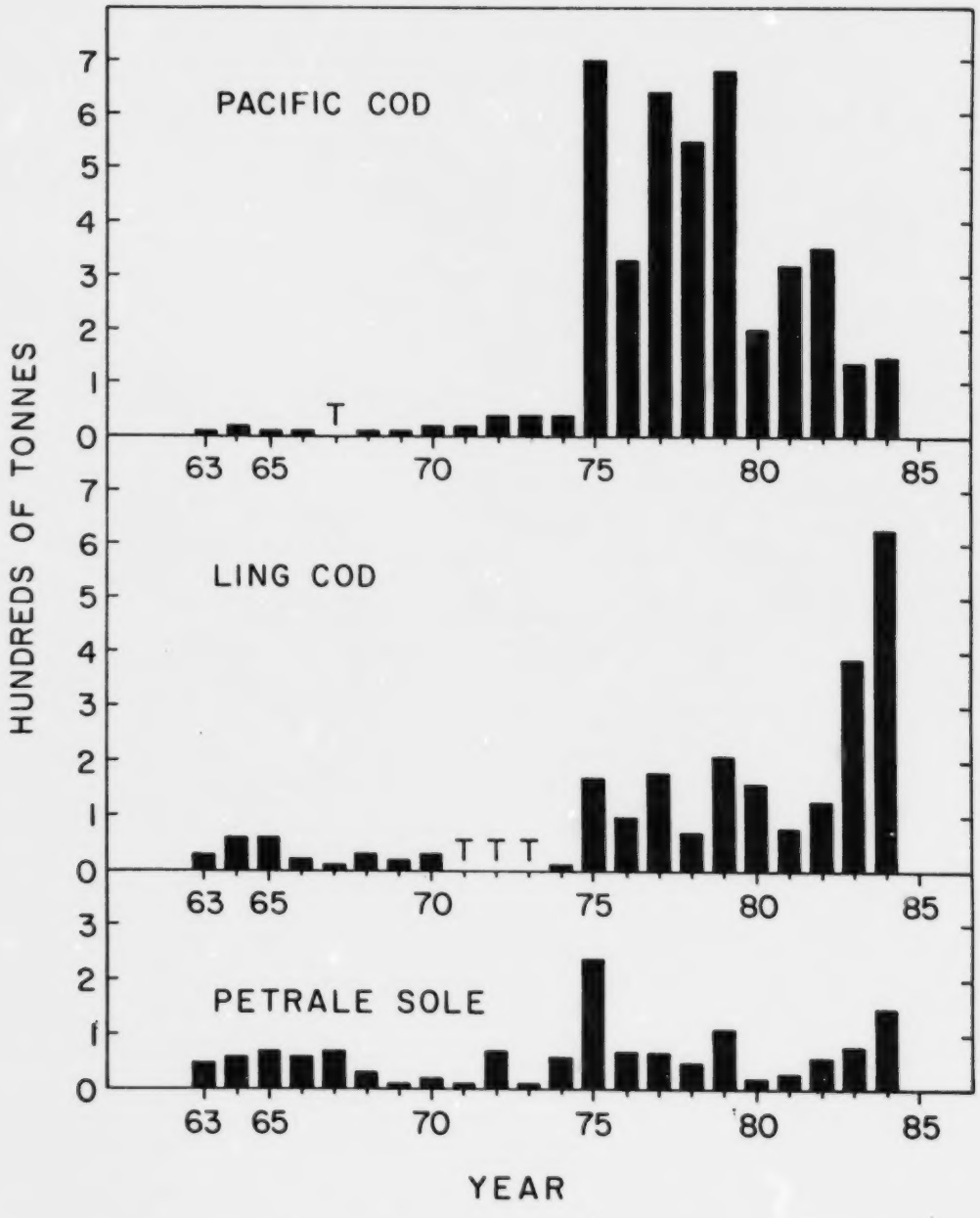


Fig. 11. Washington State landings (t) of Pacific cod, lingcod, and petrale sole from Area 3C-S during April-September 1963-84.

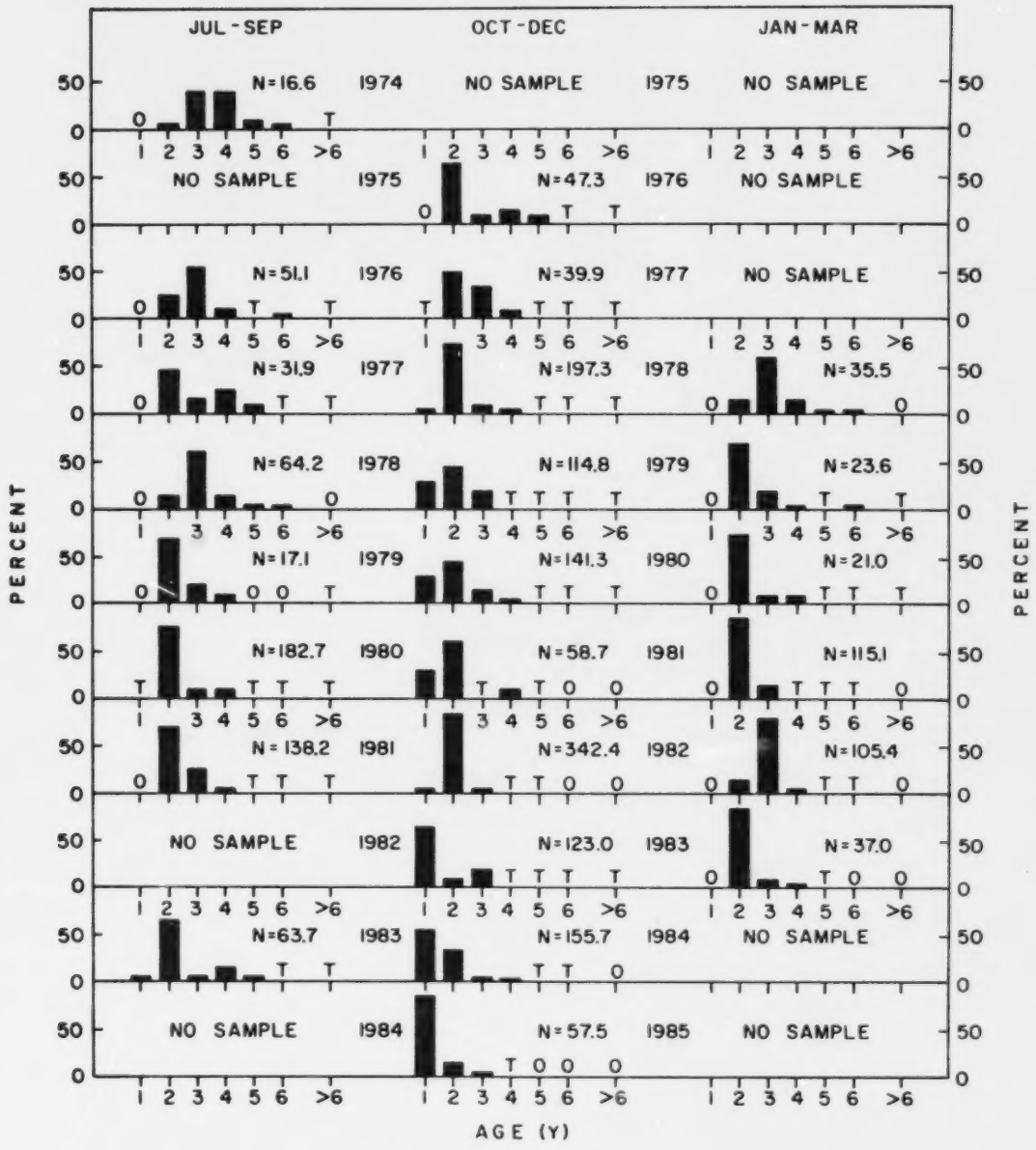


Fig. 12. Age-frequencies (%) of Pacific cod landed from MSA 19, July-September, October-December, and January-March, 1974-84.

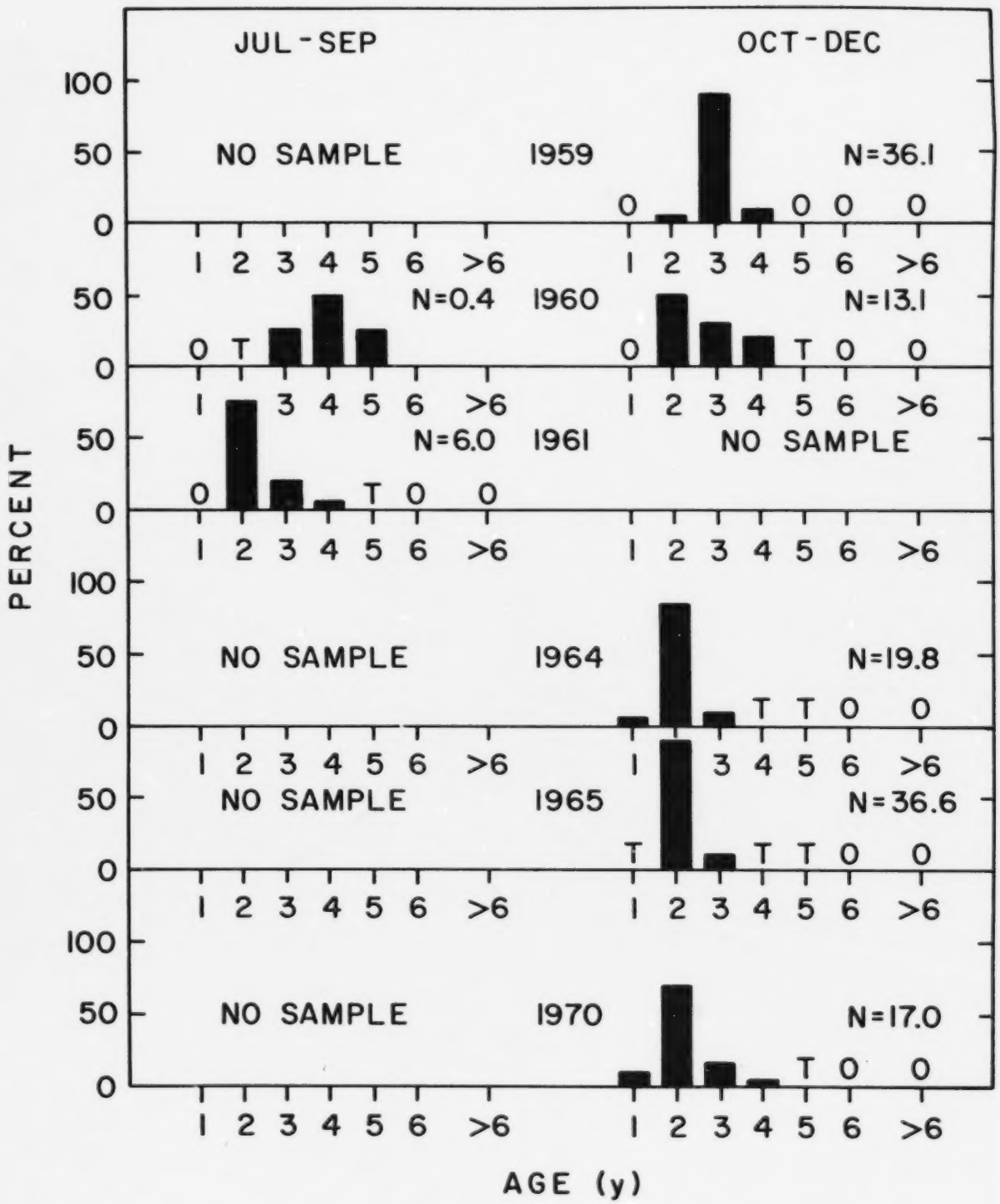


Fig. 13. Age-frequencies (%) of Pacific cod landed from MSA 19, July-September 1960-61, and October-December 1959-60, 1964-65, and 1970.